THESIS

Effect Of Fertilizers On Farm Crops

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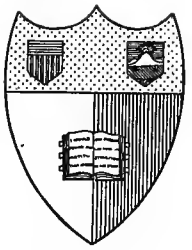
1912



A MINOR THESIS

Presented

to the Faculty of Cornell University

in Partial fulfillment of the work proscribed

for the

DEGREE OF MASTER OF SCIENCE IN AGRICULTURE

September 1, 1912.

ON THE EFFECT OF VARIOUS FERTILIZERS

ON SOME WELL KNOWN FARM CROPS

By

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FOREWORD

The yearly fertilizer bill of the American farmer reaches into an amazing total. The best estimates give as the value of farm fertilizers for one year the sum of $114,844,000.[1] One half of this is expended on the farms of the South Atlantic States. The states of Georgia and the two Carolinas are the heaviest contributors to this fund. One fourth of the total amount is used in the states bordering the North Atlantic seaboard. The amount used by the middle western and far western states is relatively small although of late years the use of fertilizers has greatly increased due largely to the propaganda carried on by a few meat packing firms in an effort to find an outlet for the by-products of their factories.

The use of commercial fertilizers is essentially a soil problem and has been considered such in the multitudinous fertilizer experiments carried on by the federal and state experiment stations in this country. It is still a mooted question, "Can the fertility of our agricultural soils be permanently maintained without the addition of a mineral fertilizer?" Whitney[2] asserts that this is possible while Hopkins[3] insists that the assumption is absurd. The preponderance of scientific evidence supports the latter theory.

A careful study of the classic experiments of seventy years standing at Rothamstead England[4] and the work done in our own

(5) (6) (7)
country at Pennsylvania, Ohio and Illinois show clearly that a judicious use of commercial fertilizers tends to maintain and build up the fertility of any given soil. The recuperative power of a soil, however, is often underestimated or ignored. A field at Rothamstead was allowed to go back to grass and weeds for twenty years and during that time had accumulated nitrogen at the rate of 44 pounds per acre each year. (4)-(page 139).

A CROP STUDY

The following study of the effect of various fertilizers is a crop not a soil study. The direct effedt of the three essential elements, nitrogen, potash and phosphorus on a few well known farm crops was observed. In no sense of the word is it a treatise on rotations or the effect of rotations on yields. Cumulative effects of fertilizers were not considered. It was essentially a one year study.

THE CROPS STUDIED

Five well known crops were examined; wheat, oats, corn, potatoes and hay. Wheat and oats are non-cultivated general field crops. Corn and potatoes are both cultivated crops, but potatoes unlike corn is capable of more intense culture and is essentially a truck garden crop. Hay is a perennial and requires little or no attention after it is once sown. All five are fairly representative of the large list of northern grown American field crops.

SOURCES OF INFORMATION

The data comprising the following tables were compiled from the publications of the state and federal experiment stations. Both the annual reports and the regular bulletins were freely drawn on. In all cases the original report of the fertilizer trial was used. In the majority of instances the experiment was conducted on the grounds of the station or sub-station. Some of the trials, however, notably, those from Connecticut are cooperative experiments with first-class farmers. In every case, however, the experiment has been under the trained eye of an expert.

METHODS OF COMPILING DATA

The following points were kept in mind in selecting typical fertilizer trials for compilation -

1 - Check or comparison plots were essential. Surprising as it may seem scores of fertilizer trials were disregarded because check plots were lacking.

2 - Only first year data was obtained. No yields were accepted that showed the cumulative effect of fertilizers.

3 - Any trial in which standard fertilizers were not used was ignored. Sodium nitrate was the carrier of nitrogen, potassium chloride, potash, and acid phosphateof phosphorus. No ready mixed fertilizer was allowed. Barnyard manure was not considered in any of the trials.

4 - In every case possible the previous history of the ground was noted and the nature of the soil determined.

5 - Original data on each trial was used. Summaries of a series of trials were not considered. Plots either one-tenth or one-twentieth acre size were almost invariably chosen.

DISTRIBUTION OF FERTILIZER TRIALS

The following series of tables are compiled from data gathered in 32 states and representing 315 separate experiments. Table 1 shows the location by states and distribution by crops. A limited number of trials are shown for oats and hay. 54 tests of wheat, 58 of potatoes and 161 of corn completes the list. The number of experiments from Connecticut, especially with corn, is very striking. Many of these were cooperative trials with farmers and were very carefully planned and executed.

The earliest of the Connecticut experiments were the first fertilizer trials in this country and were planned by Professor Samuel Johnson in 1877-8. It is a significant fact that a great many of the trials carried on later by experimenters in other states were identical in many respects with the early Connecticut experiments. This had the effect of causing less chance for error in figuring fertilizer values.

Tables 2, 3, 4, and 5 give the average yield per acre of the five crops in a summary by states. Eight plots are represented in each table. The check plot received no fertilizer. N. received nitrogen only, K. potash only, P. phosphorus, NK. nitrogen and potash, NP. nitrogen and phosphorus, KP. potash and phos-

TABLE 1.

LOCATION AND DISTRIBUTION OF FERTILIZER TRIALS.

State	Wheat	Oats	Corn	Potatoes	Hay	No. of Trials
Alabama	--	1	12	1	0	14
Arkansas	1	1	1	3		6
Colorado				1		1
Connecticut		1	52	8	3	64
Delaware			4		1	5
Georgia			7	3		10
Illinois	9		5	1	1	16
Indiana	2	4				6
Kansas	2		2			4
Kentucky	6	1	11	5	2	25
Louisiana			3	2		5
Maine					1	1
Maryland	1			3		4
Massachusetts			2	1	4	7
Michigan				1		1
Minnesota	16	2	10			28

TABLE 1. (CONT.)

Mississippi			10			10
Missouri	1					1
New Hampshire				1	2	3
New Jersey		2		9	3	14
New York				1		1
North Carolina			2	1		3
Ohio	3	1	16	4		24
Oregon				1		1
Pennsylvania			1	2		3
Rhode Island					11	11
South Carolina	1	1	8			10
Tennessee	4		4	2		10
Texas	2		2	7		11
Virginia	2					2
West Virginia	4		8			12
Wisconsin			1	1		2
Totals	54	14	161	58	28	315

TABLE 3.

AVERAGE YIELD OF OATS IN BUSHELS PER ACRE. SUMMARY BY STATES.

State	No. of Trials	Check	N	K	P	NK	NP	KP	NKP
Alabama	1	35.55	--	--	32.56	--	--	--	--
Arkansas	1	33.50	50.30	43.00	50.83	--	49.27	--	--
Connecticut	1	21.85	--	--	--	--	--	21.27	31.87
Indiana	4	41.21	(1) 21.50	(1) 26.20	(1) 27.30	(1) 28.30	(1) 26.30	(1) 31.30	50.92
Kentucky	1	27.60	37.10	30.40	--	--	--	--	--
Minnesota	2	67.50	68.75	67.75	65.87	--	--	--	74.37
New Jersey	2	32.72	--	36.50	38.35	--	--	38.35	--
Ohio	1	44.02	47.20	59.50	46.90	48.40	48.40	45.00	48.42
South Carolina	1	7.41	6.27	7.84	4.95	12.96	12.18	6.79	13.81
Total	14								

TABLE 4.

AVERAGE YIELD OF CORN IN BUSHELS PER ACRE. SUMMARY BY STATES.

State	No. of Trials	Check	N	K	P	NK	NP	KP	NKP
Alabama	12	16.53	(1) 13.12	15.44	17.48	--	--	16.59	(1) 21.20
Arkansas	1	20.50	32.00	14.00	19.00	--	--	--	--
Connecticut	52	25.37	29.60	28.65	29.78	36.52	35.60	35.89	40.34
Delaware	4	45.68	54.87	48.90	47.12	67.90	60.22	45.35	60.55
Georgia	7	25.30	27.38	20.23	25.00	24.20	26.73	25.09	29.13
Illinois	5	60.63	58.96	57.02	63.92	--	--	--	47.67
Kansas	2	44.11	50.22	46.82	43.80	--	--	--	(1) 32.28
Kentucky	11	34.84	38.20	37.30	39.00	41.94	43.28	41.54	45.40
Louisiana	3	16.39	24.16	14.60	20.50	--	--	12.44	23.55
Massachusetts	2	27.15	38.53	31.46	32.53	52.80	40.00	34.26	48.40
Minnesota	10	51.56	50.30	55.00	52.75	--	--	--	54.68
Mississippi	10	31.17	(3) 48.02	32.45	36.60	(1) 45.10	--	33.94	--
North Carolina	12	15.87	--	18.87	21.62	--	--	20.06	--
Ohio	16	44.19	46.26	46.23	47.41	53.12	57.94	55.16	57.45
Pennsylvania	1	34.30	--	32.60	37.00	--	--	37.60	36.80
South Carolina	8	14.92	(4) 13.44	(5) 19.18	(5) 19.33	(4) 12.57	(3) 16.13	(5) 20.79	15.91

TABLE 4. (CONT.)

Tennessee	4	38.17	45.50	36.62	44.13	44.48	54.68	49.20	46.63
Texas	2	22.65	22.85	22.75	25.21	--	--	--	--
Wisconsin	1	35.30	--	--	44.00	--	--	34.00	--
West Virginia	8	44.24	--	36.66 (4)	--	60.77 (4)	--	51.81	--
Total	161								

TABLE 5.

AVERAGE YIELD OF POTATOES IN BUSHELS PER ACRE. SUMMARY BY STATES.

State	No. of Trials	Check	N	K	P	NK	NP	KP	NKP
Alabama	1	89.80	--	66.53	75.16	--	--	--	--
Arkansas	3	131.22	--	(2) 191.00	131.97	--	--	130.57	207.45
Colorado	1	464.33	--	534.00	--	--	--	--	492.50
Connecticut	8	84.66	(4) 95.40	(4) 122.62	103.26	(4) 115.35	118.94	158.83	185.90
Georgia	3	17.75	(2) 22.00	20.77	33.28	31.05	39.60	34.48	78.35
Illinois	1	60.00	55.50	43.50	56.50	75.70	66.50	57.50	50.00
Kentucky	5	76.90	(4) 68.95	(4) 99.85	(4) 69.87	137.35	105.67	154.12	169.05
Louisiana	2	154.79	--	198.30	249.74	--	--	187.24	--
Maryland	3	62.93	--	--	70.99	--	--	67.08	--
Massachusetts	1	95.53	103.33	162.00	98.33	218.34	114.00	203.35	202.67
Michigan	1	55.50	--	--	--	--	--	--	44.00
North Carolina	1	100.00	--	135.00	127.50	--	--	120.00	--
New York	1	149.90	--	--	--	--	204.00	--	203.27
New Hampshire	1	94.00	90.00	124.00	124.00	132.00	114.00	208.00	209.66
New Jersey	9	98.23	--	133.28	--	--	--	131.65	149.97
Ohio	4	69.42	93.12	101.27	88.35	79.62	113.70	95.15	99.15

TABLE 5. (CONT.)

Oregon	1	81.33	89.00	226.87	227.85	--	--	--	--
Pennsylvania	2	69.00	85.00	111.50	98.00	124.50	123.00	204.50	216.00
Tennessee	2	48.87	--	--	--	--	87.65	--	105.32
Texas	7	81.78	(2) 144.20	98.78	119.94	(2) 149.52	(2) 164.22	130.06	(3) 145.53
Wisconsin	1	161.60	--	--	217.60	--	--	161.60	--

TABLE 6.

THE NUMBER OF STATES INVOLVED IN ALL OF THE FERTILIZER TRIALS.

Fertilizer	Wheat	Oats	Corn	Potatoes	Hay
Check	14	9	20	21	9
N	12	6	16	10	6
P	13	7	19	16	-
K	14	7	19	16	-
NP	8	3	10	9	-
NK	8	4	8	11	-
KP	9	5	15	15	-
NKP	9	5	14	15	5

phorus and NKP. received all three elements or what is known as a complete fertilizer. Many of the states are not represented in the complete series. Others have an insufficient number of trials and show more or less irregularity in the yields. Corn is estimated as shelled in all of the trials. It was thought best to use only the figures for the nitrogen plots and the complete fertilizer plots for hay owing to lack of sufficient data.

In tables 6 and 7 is given a resume of the number of states involved in the trials and the number of trials with each crop. The checks represent the total number of experiments studied.

Table 8 gives the average production per acre of all fertilizer trials under consideration.

TABLE 7.

THE NUMBER OF FERTILIZER EXPERIMENTS STUDIED WITH EACH CROP.

Fertilizer	Wheat	Oats	Corn	Potatoes	Hay
Check	54	14	161	58	28
N	43	7	108	22	12
P	45	9	136	37	-
K	52	9	131	39	-
NP	19	3	88	21	-
NK	17	4	82	25	-
KP	23	6	118	46	-
NKP	33	9	118	40	18

It can be seen readily that where a larger number of plots are represented in one fertilizer series than in another an element of error is introduced. Comparing the nitrogen series in wheat compiled from those states where the yield of wheat is invariably low with the potash series where the wheat yields are normal is manifestly unfair. To eliminate this source of error each of the seven fertilizer plots was compared directly with its check plot. Tables 9, 10, 11, 12 and 13 furnish a comparison with the check plots. All calculations showing the increase by means of fertilizers and when estimating the value of the increase were made in this way.

TABLE 8.

AVERAGE PRODUCTION PER ACRE OF ALL FERTILIZER TRIALS UNDER CONSIDERATION.

Fertilizer	Wheat Bus.	Oats Bus.	Corn Bus.	Potatoes Bus.	Hay lbs.
Check	16.44	38.09	31.56	91.88	2401
N	16.86	42.84	37.76	85.01	3315
K	17.26	41.72	33.87	121.98	--
P	19.61	41.22	35.31	107.69	--
NK	18.34	29.89	40.97	112.64	--
NP	20.43	34.04	41.96	112.03	--
KP	18.93	30.34	35.99	132.05	--
NKP	20.74	49.61	43.05	163.01	4205

INFLUENCE OF NITROGEN

Corn and hay showed the greatest increase from the use of nitrogen. The influence exerted on the yield of corn is especially noteworthy. In combination with either of the two minerals it seemed more effective than when used alone. Its influence on wheat and oats was not especially striking while on potatoes it seemed in some of the trials to be a positive injury. The greater availability of a nitrogen fertilizer gives it an advantage over the slower acting potash and phosphorus carriers in any first year trial.

TABLE 9.

A COMPARISON WITH CHECK PLOTS IN THE FERTILIZER TRIALS WITH WHEAT.

No. of Trials	Fertilizer	Yield Per Acre	Bus. Increase	Value of Increase
43	Check)	15.65		
	N)	16.86	1.21	$1.10
45	Check)	15.43		
	K)	17.26	1.83	1.66
52	Check)	16.41		
	P)	19.61	3.20	2.91
19	Check)	15.06		
	NK)	18.34	3.28	2.98
17	Check)	15.05		
	NP)	20.44	5.39	4.90
23	Check)	15.16		
	KP)	18.95	3.79	3.45
33	Check)	14.62		
	NKP)	20.74	6.12	5.57

TABLE 10.

A COMPARISON WITH CHECK PLOTS IN THE FERTILIZER TRIALS WITH OATS.

No. of Trials	Fertilizer	Yield Per Acre	Bus. Increase	Value of Increase
7	Check)	38.42		
	N)	42.84	4.42	$1.87
9	Check)	37.15		
	K)	41.72	4.57	1.93
9	Check)	38.04		
	P)	41.22	3.18	1.34
3	Check)	24.94		
	NK)	29.89	4.95	2.09
4	Check)	27.08		
	NP)	34.04	6.96	2.94
6	Check)	27.02		
	KP)	30.34	3.32	1.40
9	Check)	41.24		
	NKP)	49.61	8.37	3.54

TABLE 11.

A COMPARISON WITH CHECK PLOTS IN THE FERTILIZER TRIALS WITH CORN.

No. of Trials	Fertilizer	Bus. Per Acre	Bus. Increase	Value of Increase
108	Check)	34.30		
	N)	37.76	3.46	$1.95
136	Check)	31.66		
	K)	33.87	2.21	1.24
131	Check)	32.41		
	P)	35.31	2.90	1.63
88	Check)	32.16		
	NK)	40.97	8.81	4.96
82	Check)	31.38		
	NP)	41.96	10.58	5.96
118	Check)	30.36		
	KP)	35.99	5.63	3.17
118	Check)	32.12		
	NKP)	43.05	10.93	6.16

TABLE 12.

A COMPARISON WITH CHECK PLOTS IN FERTILIZER TRIALS

WITH POTATOES.

No. of Trials	Fertilizer	Bus. Per Acre	Bus. Increase	Value of Increase
22	Check)	76.08		
	N)	85.01	8.93	$5.77
37	Check)	93.87		
	K)	121.98	28.11	18.15
39	Check)	81.44		
	P)	107.69	26.25	16.95
21	Check)	83.25		
	NK)	112.64	29.39	18.98
25	Check)	77.09		
	NP)	112.03	34.94	22.56
46	Check)	83.00		
	KP)	132.05	49.05	31.67
40	Check)	93.63		
	NKP)	163.01	69.38	44.81

TABLE 13.

A COMPARISON WITH CHECK PLOTS IN THE FERTILIZER TRIALS WITH HAY.

No. of Trials	Fertilizer	Lbs. Per Acre	Lbs. Increase	Value of Increase
12	Check)	2450		
	N)	3315	865	$5.03
18	Chedk)	2258		
	NKP)	4205	1947	11.33

INFLUENCE OF POTASH

As was to be expected potash proved to be the premier fertilizer for potatoes. The potash plots gave over three times more increase than that of nitrogen. With wheat, oats and corn the yields were seriously effected when a combination of phosphorus and potash was used. Table 12, on the other hand shows the opposite effect. The NK plots here have an average very little greater than either potash or phosphorus alone.

INFLUENCE OF PHOSPHORUS

Wheat was the outstanding crop effected by the addition of phosphate fertilizer. The yield of oats was considerably lower where phosphorus was applied than in the nitrate and potash plots.

A combination of nitrogen and phosphorus gave an increase of 6.96 bushels while a similar combination of potash and phosphorus gave an increase of 3.32 bushels per acre, less than half as much. Table 11 shows the same results with corn. Potatoes seems to be the only crop of the four studied where a combination of potash and phosphorus was not detrimental when compared to the increase from the other fertilizers.

THE CARRIERS OF NITROGEN, POTASH AND PHOSPHORUS

Nitrate of soda ($NaNO_3$), sodium nitrate or Chile saltpeter, was the commercial form of nitrogen fertilizer used in the trials. Muriate of potash (KCl) was the carrier of potash. Dissolved rock phosphate or acid phosphate which contains about 14 per cent. of phosphoric acid was the standard fertilizer in the application of phosphorus.

In table 14 is given the commercial form, the amount per acre, the cost per ton and the cost per acre of the fertilizers used in the 315 trials with wheat, oats, corn, potatoes and hay.

AMOUNT OF FERTILIZER PER ACRE

Owing to the remarkable influence exerted by Professor Samuel Johnson in Connecticut a very large number of the trials under consideration had the same amounts of fertilizer given in the accompanying table. All trials showing amounts used greatly in excess of this schedule or those running under it were omitted in the calculation.

TABLE 14.

KINDS AND APPROXIMATE AMOUNTS OF FERTILIZERS PER ACRE USED IN 315 TRIALS WITH WHEAT, OATS, CORN, POTATOES AND HAY.

Fertilizer	Commercial Form	Amount Per Acre in lbs.	Cost Per Ton	Cost Per Acre
N	Nitrate of soda	160	$60.00	$4.80
K	Muriate of potash	160	45.00	3.60
P	Acid Phosphate	320	15.00	2.40
NK		160 160		8.40
NP		160 320		7.20
KP		160 320		6.00
NKP		160 160 320		10.80

In figuring cost of the increase where so many trials were involved it was manifestly impossible to use anything but a constant for the amount of fertilizers applied as well as the cost per ton.

COST PER TON

In charging any crop with the cost of an application of fertilizer, labor in applying it to the land should be figured in as well as the cash price paid for the actual ingredients. No attempt is made to get at the actual cost in cents of hauling, mixing and applying but the cost affixed is high enough to include incidental expenses of the farmer who uses fertilizers. Sodium nitrate at $60.00 a ton is higher than when the bulk of the trials were being conducted but no higher than present prices of fertilizers would warrant.

VALUE OF INCREASE

In estimating the value of the increase the average farm prices for the five years 1907-11 were taken. Potatoes were worth 64.58 cents; corn, 56.32 cents; wheat, 90.98 cents; oats, 42.28 cents, and hay $11.64 a ton. These values are used in the calculations in tables 9 - 13.

NET PROFITS PER ACRE

Without exception the average yield of each crop has been increased by the use of a single fertilizing element and by the addition of any two of the three forms as well as the complete

fertilizer itself. Of greater importance, however, than yield is the answer to the question "Does it pay?" Only a series of years would properly answer that question but even granting that the application of mineral fertilizers is necessary for the maintenance of soil fertility,(an assertion not yet conclusively proven), it is very important for the farmer to know whether he can expect immediate returns from his outlay or depend on the cumulative effect of his applications of fertilizers on future crops. Table 15 answers the question for the first year. A perusal of the table clearly shows that with the exception of potatoes and hay fertilizers do not act as a quick investment. The gain columns are blank with the exception of the phosphorus plot in wheat. Here a gain of 51 cents per acre is registered. The losses on oats are particularly severe. The gain column marked potatoes is the one striking feature of the table. Even nitrogen was a paying investment and where complete fertilizer was used the greatest profit was reached. One of the experimenters stated, "the larger the application of fertilizer the larger the yield". (9) This fact is generally taken advantage of by truck farmers in the Long Island region of New York where 1000 pounds of fertilizer per acre is not at all unusual.

The use of nitrogen on hay shows a slight gain and it is to be regretted that more data is not available on this very important subject. This crop was at a slight disadvantage compared with the other four as the fertilizer was applied to the

TABLE 15.

NET PROFIT PER ACRE OF THE INCREASE FROM THE USE OF FERTILIZERS.

	Wheat		Oats		Corn		Potatoes		Hay	
Fertilizer	Gain	Loss	Gain	Loss	Gain	Loss	Gain	Loss	Gain	Loss
Check	--	--	--	--	--	--	--	--	--	--
N	--	3.70	--	2.93	--	2.85	.97	--	.23	--
K	--	1.94	--	1.67	--	2.36	14.55	--	--	--
P	.51	--	--	1.06	--	.77	14.55	--	--	--
NK	--	5.42	--	6.31	--	3.44	10.58	--	--	--
NP	--	2.30	--	4.26	--	1.24	15.36	--	--	--
KP	--	2.55	--	4.60	--	2.83	25.67	--	--	--
NKP	--	5.23	--	7.26	--	4.64	34.01	--	.53	--

TABLE 16.

CORN YIELDS IN FERTILIZER TRIALS ON CLAY SOILS COMPARED WITH YIELDS ON SANDY SOILS.

	CLAY SOIL		SANDY SOIL	
Fertilizer	No. of Trials	Bus. Per Acre	No. of Trials	Bus. Per Acre
Check	54	30.56	38	27.97
N	31	31.71	29	37.30
K	40	30.58	35	31.73
P	37	32.29	36	31.21
NK	33	37.83	27	46.93
NP	29	37.66	27	43.21
KP	43	39.88	35	34.49
NKP	39	40.81	30	44.60

surface of the ground and was not incorporated directly into the soil.

YIELDS ON CLAY AND SANDY SOILS

The type of soil was carefully described in most of the fertilizer trials. In the corn experiments 54 were selected as being conducted on a clay soil while 38 were carried on in a soil considered sandy. Clay soils are not necessary fertile nor sandy land unproductive but a comparison of the relative influence of fertilizers on the types of soil was desired. Table 16 shows the average yields for corn and table 17 shows the same thing for potatoes. Owing to the small number of trials involved in potatoes

TABLE 17.

POTATO YIELDS IN FERTILIZER TRIALS ON CLAY SOIL COMPARED WITH YIELDS ON SANDY SOILS.

	CLAY SOIL		SANDY SOIL	
Fertilizer	No. of Trials	Bus. Per Acre	No. of Trials	Bus. Per Acre
Check	15	73.73	17	84.37
N	7	79.55	4	59.95
K	8	99.20	10	106.65
P	11	78.49	9	97.71
NK	7	120.26	4	49.62
NP	9	96.49	4	81.90
KP	12	120.33	13	103.12
NKP	11	138.63	12	135.35

the yields fluctuate. The yields of corn on the lighter soil respond somewhat better to the application of fertilizer than those on the heavy soil.

Tables 18 and 19 show a direct comparison of both crops with checks. Table 20 brings this out more clearly with respect to corn. The sand column gives a substantial increase over clay with the exception of both the phosphorus plots which are in favor of clay. Why this should be so is not altogether clear and only a more intimate study of each of the soils involved would answer the question.

TABLE 18.

A COMPARISON WITH CHECK PLOTS WITH CORN ON CLAY SOILS AND SANDY SOILS.

	CLAY SOIL		SANDY SOIL	
Fertilizer	Bus. Per Acre	No. of Trials	Bus. Per Acre	No. of Trials
Check)	29.05	23	31.41	29
N)	31.71		37.30	
Check)	28.70	14	28.37	35
K)	30.58		31.73	
Check)	27.36	17	28.56	36
P)	32.29		31.21	
Check)	31.70	21	32.13	27
NK)	37.83		46.93	
Check)	28.97	25	32.13	27
NP)	37.66		43.21	
Check)	30.75	11	28.88	35
KP)	39.88		34.49	
Check)	28.80	15	31.30	30
NKP)	40.81		44.60	

TABLE 19.

A COMPARISON WITH CHECK PLOTS WITH POTATOES ON CLAY SOILS AND SANDY SOILS.

Fertilizer	CLAY SOILS		SANDY SOILS	
	Bus. Per Acre	No. of Trials	Bus. Per Acre	No. of Trials
Check)	71.01	7	37.34	7
N)	79.55		59.95	
Check)	73.36	8	79.73	10
K)	99.20		106.65	
Check)	70.52	11	80.79	9
P)	78.49		97.91	
Check)	71.01	7	37.34	4
NK)	120.26		49.62	
Check)	66.09	9	37.34	4
NP)	96.49		81.90	
Check)	76.53	12	79.17	13
KP)	120.23		103.12	
Check)	75.21	11	75.07	12
NKP)	138.63		135.35	

TABLE 20.

A COMPARISON OF THE INFLUENCE OF VARIOUS FERTILIZERS OVER CHECKS ON CLAY SOILS AND SANDY SOILS IN YIELDS OF CORN.

	CLAY	SAND		
Fertilizer	Bus. Increase Over Checks	Bus. Increase Over Checks	Difference in favor of Clay	Difference in favor of Sand
N	2.66	5.89	--	3.23
K	1.88	3.36	--	1.48
P	4.93	2.65	2.28	--
NK	6.13	14.80	--	8.67
NP	8.69	11.08	--	2.39
KP	9.13	5.61	3.52	--
NKP	12.01	13.30	--	1.29

A similar situation exists with the two types of soils upon which potatoes were grown. Where potash was applied a large increase is noted on the clay soils although the number of trials was too small to allow a correct comparison on the NK plots. The complete fertilizer plot shows an increase in favor of clay.

CORN ON GRASS LAND

Out of the 161 trials with corn 39 of them were on grass land. The yields on these plots are compared with the yields on all the corn trials in tables 22 and 23. It must be remembered the totals for the grass land plots are included in the averages

TABLE 21.

A COMPARISON OF THE INFLUENCE OF VARIOUS FERTILIZERS OVER CHECKS ON CLAY SOILS AND SANDY SOILS IN YIELDS OF POTATOES.

	CLAY	SAND		
Fertilizer	Bus. Increase Over Checks	Bus. Increase Over Checks	Difference in favor of Clay	Difference in favor of Sand
N	8.54	22.61	--	14.07
K	25.84	26.92	--	1.08
P	7.87	16.92	--	9.05
NK	49.25	12.28	36.97	--
NP	30.40	44.56	--	14.16
KP	43.70	23.95	19.75	--
NKP	63.42	60.28	3.14	--

for all the corn plots. This, of course, would have a tendency to raise the general average of plot yields and lower the amount of increase. The difference is shown in the last column of table 22 and is rather striking. All of the yields of corn on the grass plots were substantially higher than the general average.

COMMENTS OF EXPERIMENTERS

Cornell Bul. 4-53-57 - I.P.Roberts. "No results in the corn crop can be traced to the use of fertilizers."

TABLE 22.

A COMPARISON OF THE AVERAGE YIELDS OF CORN PLANTED ON GRASS LAND WITH THE AVERAGE YIELDS OF ALL CORN TRIALS.

	GRASS LAND		ALL CORN TRIALS		
Fertilizer	No. of Trials	Bus. Per Acre	No. of Trials	Bus. Per Acre	Difference in favor of Grass Land
Check	39	36.90	161	31.56	5.34
N	33	42.04	108	37.76	4.28
K	34	39.53	136	33.87	5.66
P	33	39.34	131	35.31	4.03
NK	33	45.14	88	40.97	4.17
NP	31	46.05	82	41.96	4.09
KP	35	45.18	118	35.99	9.19
NKP	34	47.40	118	43.05	4.35

Ohio Bul.-Vol.4, No. 8 - Page 179.

"These statistics indicate that the wheat crops of Ohio have been slightly increased by the use of commercial fertilizers, but it appears that the average cost of this increase has equalled its market value."

"A dollar expended in fertilizers has produced approximately one bushel of wheat."

Georgia Bul. 14 - Page 74,

"Nitrogen is the most effective element as a fertilizer for oats on this land."

TABLE 23.

A COMPARISON WITH CHECKS OF CORN GROWN ON GRASS LAND WITH CORN ON ALL THE FERTILIZER PLOTS.

Fertilizer	No. of Trials	GRASS LAND Bus. Per Acre	Bus. Increase Over Checks	Bus. Increase over checks in all trials	Difference in favor of Grass
Check)	33	37.01	4.37	3.46	.91
N)		41.38			
Check)	34	36.31	1.03	2.21	-1.18
K)		37.34			
Check)	33	37.01	.09	2.90	-2.81
P)		37.10			
Check)	33	35.83	9.38	8.81	.57
NK)		45.21			
Check)	31	34.83	13.02	10.58	2.44
NP		47.85			
Check)	35	35.01	9.95	5.63	4.32
KP)		44.96			
Check)	34	34.65	13.79	10.93	2.86
NKP)		48.44			

Indiana Bul. 34 - Page 67.

"The results obtained thus far do not encourage the use of fertilizers or manures for oats on ground whose natural fertility will produce in a favorable year 50 to 55 bushels of corn per acre."

Georgia Bul. 23 - Page 74-78.

"Commercial fertilizers at present prices are not profitable on the soil covered by the experiment, when planted in corn."

Maryland Bul. 46 - Page 53.

"The average results of three years' experiments in fertilizing corn would indicate that it is not profitable to apply fertilizer to this crop on our soil."

North Carolina Bul. 65 - Page 45.

"The addition of fertilizers did not increase the yield to a basis approaching a paying one."

SUMMARY

1. Nitrogen was the most effective fertilizing element in increasing the yields of corn and hay.

2. Phosphorus influenced the yield of wheat more decidedly than either nitrogen or potash.

3. Potash was by far the most effective fertilizing constituent with potatoes.

4. Each single fertilizer and every combination of fertilizers increased the yield of all five crops studied.

5. With the exception of phosphorus applications to the wheat crop, fertilizers on wheat, oats and corn did not pay the first year.

6. All fertilizers paid a handsome return with potatoes. The greater the amount of fertilizer the larger the yield so far as the results of these experiments go.

7. Nitrogen fertilizer applied to the hay crop gave a small margin of profit.

8. Sandy soils responded more readily to fertilizers than clay soils when growing a crop of corn.

9. A noticeable increase in the yields of corn was obtained in the fertilizer trials when grown on grass land.

BIBLIOGRAPHY

1. 1910 U. S. Census Reports
2. Bulletin 22. Bureau of Soils.
3. Soil Fertility and Permanent Agriculture. C.G.Hopkins.
4. The Book of the Rothamsted Experiment. A.D.Hall.
5. Pennsylvania bulletin 90.
6. Ohio Bulletins 182, 183 and 184.
7. Illinois Bulletin 123.
8. Year Book for 1911.
9. Bulletin 65, North Carolina - Page 37.